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Model Verification and Structural Stiffness Evaluation for Utility Vehicle Frame Structure

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Abstract—The strength of vehicle frame structure is a major concern for safety. This work applies computer aided engineering (CAE) and experimental modal analysis (EMA) techniques to study a utility vehicle (UV) frame structure. The idea of model verification is presented for validating the developed analytical model created by finite element (FE) commercial software. The FE model of UV frame structure is first built to perform modal analysis so as to obtain structural natural frequencies and mode shapes. The UV frame structure is also performed EMA to experimentally determine the structural modal parameters in free boundary condition. By comparing both modal parameters obtained from FEA and EMA, the FE model can be validated base on the experimentally obtained data. The modal characteristics of the UV frame structure can be well interpreted and calibrated. The bending and torsion stiffness of the frame structure can then be predicted by the validated FE model. This work shows the integration of FEA and EMA techniques for structural model verification and response prediction, in particular applied to the UV frame structure. The layout approach can not only be beneficial to vehicle structural design as well as for structural strength evaluation but also be adopted for other components or subsystem study.

Keywords—utility vehicle, experimental modal analysis, finite element analysis, structural stiffness

1. Model Verification

Figure 1 shows the flow chart for model verification via the integration of EMA and FEA for the UV frame structure. The objective in performing model verification is to obtain validated analytical model. The agreement of modal parameters, including modal frequencies and mode shapes, between FEA and EMA indicates the analytical model is equivalent to the practical structure.

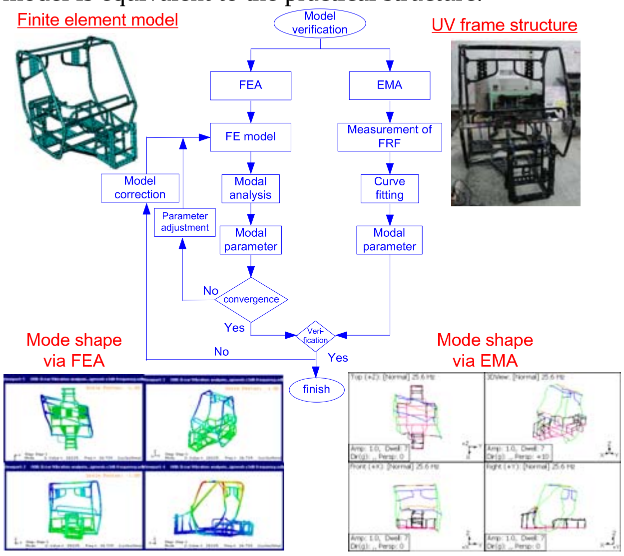

Figure 1: Model verification flow chart by integrating EMA and CAE techniques.

2. Design Modification

Figure 2 reveals the flow chart in structural design modification. The first step is to conduct model verification to validate the analytical model. The next step is to perform response prediction via the validated model. In this work, the structural stiffness of the UV frame is evaluated. Finally, if the structural modification is required in order to meet the design specification, the model modification will be carried out and repeated to achieve the design goal.

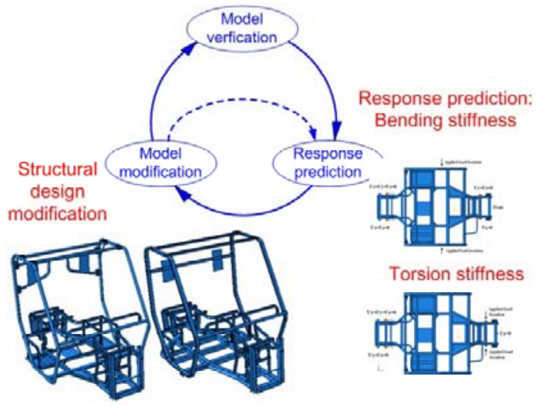

Figure 2: Structural design modification flow chart for CAE and EMA.

3. Conclusions

- This work combines FEA and EMA techniques to perform model verification of a 3D UV frame structure.
- Results show modal parameters obtained from FEA and EMA agree reasonably. The analytical FE model can be validated and used for further analysis.
- The bending and torsion stiffness of the UV frame structure are determined and used for further design modification, in particular for reducing the weight of frame structure.
- This work provides a systematic approach by the integration of FEA and EMA for structural design analysis and can be adopted for other vehicle component and subsystem design.